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EVALUATION OF LOSS OF (+)-DISPARLURE FROM GYPSY MOTH (LEPIDOPTERA: LYMANTRIIDAE) PHEROMONE DISPENSER TAPES UNDER FIELD CONDITIONS IN FLORIDA

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ABSTRACT

The residual pheromone content of laminated plastic, pheromone-dispensing tapes impregnated with (+)-disparlure, the sex pheromone of the gypsy moth, *Lymantria diapar* (L.), was assessed after exposure to field conditions in Gainesville. As determined by gas chromatography, lure tapes deployed on 26 August 1991 rapidly lost pheromone during the first 2 months in the field. Loss of pheromone was considerably less for the remaining 4-month exposure period (28 October 1991 to 3 March 1992). Lure tapes at 5 locations differed slightly in their rates of pheromone loss, and traps placed on the north side of tree trunks retained more pheromone than traps placed on the south side. These data indicate that a pheromone lure used for monitoring gypsy moth during spring and early summer in north Florida may lose its effectiveness rapidly and may have to be replaced more often than is currently recommmended for other regions of the country.

Key Words: *Lymantria dispar*, sex pheromone, pheromone trap, population monitoring, gas chromatography.

RESUMEN

Se evaluaron después de exposición a las condiciones de campo en Gainesville, Florida, U.S.A., el contenido residual de feromona de plástico laminado, cintas de dispensar feromona impregnadas con (+)-disparlure, la feromona de la polilla gitana, *Lymantria dispar* (L.). Segun análisis por cromotografía de gas, cintas atrayentes col-

ocadas 26 de agosto de 1991 perdieron rapidamente la feromona durante los primeros dós meses en el campo. La pérdida fue considerablemente menos durante el período restante de 4 meses (28 de octubre de 1991 hasta 3 de marzo de 1992). Cintas atrayentes en 5 localidades difieron ligeramente en la tasa de pérdida de la feromona, y trampas colocadas en el lado norte de troncos de arboles retuvieron mas feromona que las trampas colocadas en el lado sur. Estos datos indican que un atrayente de feromona usado para monitoreo de la polilla gitana durante la primavera y los principios de verano en el norte de la Florida podría perder su efectividad rapidamente y tener que estar reemplazado mas frequentamente que se recomienda para otras regiones del país.

The larvae of the gypsy moth, *Lymantria dispar* (L.), defoliate many forest and shade trees in the northeastern United States. The gypsy moth is slowly spreading westward and southward from the northern U.S. Small outbreaks are periodically detected and eradicated on the perimeter of the main population (Schwalbe 1981, McManus et al. 1989). Detection is commonly made with traps baited with the pheromone, (+)-disparlure (R,S-7,8-epoxy-2-methyloctadecane), which attracts male gypsy moths (Bierl et al. 1970, Yamada et al. 1976).

Disparlure has potential as an effective lure for population control (Beroza & Knipling 1972, Schwalbe & Mastro 1988), and it is used for monitoring population spread (Elkinton & Carde 1980, Elkinton & Carde 1981, McManus et al. 1989). Trap catches are reliable indicators of population density (Kolodny-Hirsch & Schwalbe 1990, Thorpe et al. 1993), which is an important consideration in planning a control/eradication strategy when a new infestation is discovered.

The loss of disparlure from various dispensers and its effectiveness after deployment have been evaluated in a number of studies (Leonhardt & Moreno 1982, Leonhardt et al. 1990, Leonhardt et al. 1992). None of these studies, however, was done under the typical high temperature and high humidity conditions that exist in Florida. Although there is no known established population in Florida, small numbers of moths are captured in Florida in the spring each year (Foltz & Dixon, unpublished data), and are believed to be from egg masses laid on vehicles or other articles brought into Florida by tourists. Thus, there is concern that at some point it may be necessary to deploy large numbers of disparlure-baited traps for monitoring, control and/or evaluation of an incipient population. This report is an evaluation of the field loss of disparlure from commercial Hercon Luretape® strips in delta traps.

Materials and Methods

Pheromone-impregnated strips were from Hercon Luretape®, Lot #D0048 remaining from those used by USDA APHIS PPQ in 1991. We purchased 100 mg neat (+)-disparlure from Hercon to use in evaluating our chromatographic system. Pheromone tapes were kept in a freezer (−20° C) until used. The tapes were advertised to contain 500 μg (+)-disparlure per tape. We stapled 21 tapes into each of 10 Pherocon III D traps from Trece, Inc., P.O. Box 6278, Salinas, CA 93915. The traps were not coated with sticky material. Two traps were placed at each of five locations in Gainesville, FL, one on the north side and one on the south side of a tree at the five different locations. Traps were placed approximately 1.25 m above the ground. We removed three tapes from each trap on 26 August 1991 when the traps were initially prepared for field deployment, and thereafter at monthly intervals on 26 September, 28 October, 26 November 1991, and on 2 January, 3 February, and 3 March 1992. Each tape was removed with forceps, placed into a small vial (approximately 2 ml capacity) with screw cap containing a teflon liner, brought to the laboratory and placed into a freezer (approx-

imately −20° C) until analysis. In preparation for analysis, approximately 1.5 ml of acetone:pentane (50:50 v/v) was added to each vial to cover the tape, and a measured amount of methyl hexadecanoate (16 carbon fatty acid methyl ester-C16 FAME) in acetone:pentane (50:50) was added as an internal standard. The vials were allowed to remain on the bench top overnight to thoroughly solubilize the disparlure remaining in the tape. The quantity of C16 FAME was reduced each month to give an internal standard quantity in each vial that approximately equaled the quantity of disparlure expected to remain in the tapes. Vials were shaken thoroughly before removing approximately 1 μl for injection into the gas chromatograph.

Samples were chromatographed on a non-polar 25 m × 0.25 mm capillary column containing a bonded polydimethylsiloxane coating (Alltech RSL 150) in a Shimadzu G14-A gas chromatograph with capillary injector port and flame ionization detector (FID). The column was initially set at 150° C for 3 min, and then temperature was programmed to increased at a rate of 4° C/min to 200° C and held for 10 min. The column temperature was then raised rapidly (30° C/min.) to 290° C to drive off certain impurities that showed on chromatograms well after the elution of C16 FAME and disparlure. The injection port was set at 270° C and the FID at 320° C. Samples were injected in the splitless mode, with a purge flow of carrier after 0.5 min. The carrier gas flow (helium) was adjusted to a flow rate of 25 cm/min.

In order to evaluate C16 FAME as an internal standard, we co-chromatographed weighed samples of C16 FAME and (+)-disparlure, and calculated percent recovery of expected (weighed) (+)-disparlure from its peak area as a function of the peak area for C16 FAME. Freshly weighed samples were chromatographed initially, and again in November and December 1991, and in January 1992.

Analysis of variance was performed on residual amounts of pheromone in lure tapes (SAS Institute 1987). Means were compared using LSD test analysis at the 5% significance level.

Results and Discussion

The purity of the commercial sample of C16 FAME was 98.9% and that of disparlure was 96.8%, as determined in our GC system. Disparlure eluted from the capillary column in about 14.4 min while C16 FAME eluted at about 12.1 min throughout the 6 months the experiment was in progess. We found 99.8% ± 8.0% (mean ± SD, n = 28) of expected (weighed) samples of (+)-disparlure with C16 FAME as the internal standard. This high rate of recovery indicated that the chromatographic system was functioning well and that C16 FAME was an adequate internal standard. C16 FAME eluted about 2 min before (+)-disparlure and also contained oxygen in the molecule, as does (+)-disparlure.

The data from recovery of disparlure remaining in dispenser tapes and associated loss rates are shown in Table 1. The quantity of disparlure (mean ± SD) initially detected in tapes as the experiment began (432 ± 39 μg, range 357-521 μg, n = 30 tapes) was about 14% less than the expected 500 μg stated by the manufacturer. There may have been some loss of disparlure from the tapes during shipment and handling before we started the experiment. It may be difficult to recover all the disparlure originally incorporated into lure tapes. Leonhardt et al. (1990) found pheromone amounts in new tapes within the range of 400-500 μg.

After the traps had been in the field for one month, the residual amount of pheromone decreased to 303.7 ± 13.2 μg (Table 1). This indicates a release of 128 μg for the period, with an average loss rate of 172 ng hr^{-1} (Table 1). Residual amounts of pheromone and rate of loss continued to fall until late November and then remained nearly constant for the next 3 months.

TABLE 1. GAS CHROMATOGRAPHIC DETERMINATION OF CHANGE IN RESIDUAL AMOUNT OF (+)-DISPARLURE FROM HERCON LURETAPE® EXPOSED IN THE FIELD IN GAINESVILLE, FLORIDA, FROM AUGUST 1991 TO MARCH 1992.

Sample Date	Day	Mean ± 95% CI μg in Tape	Loss Rate μg/Day	Loss Rate ng/h
26 Aug 1991	0	432.1 ± 13.9	—	—
26 Sep 1991	31	303.7 ± 13.2	4.1	172
28 Oct 1991	63	234.1 ± 15.7	2.2	91
26 Nov 1991	92	221.8 ± 16.4	0.4	17
2 Jan 1992	129	174.6 ± 17.3	1.3	53
3 Feb 1992	161	225.6 ± 24.7	—	—
3 Mar 1992	190	198.0 ± 18.6	1.0	40

Data were pooled for all dates except the initial date when tapes were taken out of their protective packaging and immediately analyzed. As expected, analysis of variance indicated that sampling date was a major source of variability in pheromone residual amounts ($F_{5,168} = 26.55$; $P = 0.0001$). Location was also significant ($F_{4,168} = 5.59$; $P = 0.0003$). The compass direction that a trap faced was not quite significant ($F_{1,168} = 3.15$; $P = 0.0779$); however, north-facing traps retained more pheromone than south-facing traps on 5 of 6 sample dates.

Leonhardt et al. (1990) indicated that traps caught large numbers of male gypsy moths only when the lure emitted at least 30 ng h^{-1}, and had a residual content of at least 100 μg. On average, lure tapes from the present experiment in Florida provided this emission rate over the 6 months of the study, but it should be emphasized that the experiment was conducted from late August to early March. The average temperatures for these months in Gainesville are 25.7° C (September), 22.0° C (October), 17.4° C (November), 13.8° C (December), 13.0°C (January), and 13.7° C (February). The average temperatures for the last 4 months of the experiment (Table 2) are considerably cooler than historical temperatures for April (20.1° C), May (23.4° C), June (26.6° C) and July (27.4° C) when traps are most likely to be needed in north Florida to monitor gypsy moths. Leonhardt et al. (1990) found that release rates increased 3.5-fold for each 10° C increase in temperature, and the log of the release rate was proportional to the inverse of temperature (Bierl-Leonhardt et al. 1979). Summer months are also considerably more humid and rainy than fall and winter in north Florida, conditions that are likely to cause rapid aging of the pheromone lure. Lures deployed during the spring

TABLE 2. SUMMARY OF TEMPERATURE RECORD DURING THE EXPERIMENTAL PERIOD.

Time Period	Temperatures (° C) Max	Min	Average
26 Aug 91-26 Sep 91	35.6	16.7	26.3
27 Sep 91-28 Oct 91	32.2	4.4	21.3
29 Oct 91-26 Nov 91	30.0	–5.0	15.4
02 Dec 91-02 Jan 92	30.0	–3.9	15.3
03 Jan 92-03 Feb 92	25.6	–6.7	11.1
04 Feb 92-03 Mar 92	32.2	–2.8	15.4

and summer are likely to experience loss rates as high as those occurring during September (172 $\mu g\ hr^{-1}$), which would quickly deplete the lure tape of (+)-disparlure. Additional research under seasonal monitoring conditions should be conducted in order to refine recommendations for monitoring of gypsy moth in north Florida.

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SURVEY OF EVANIID WASPS (HYMENOPTERA: EVANIIDAE) AND THEIR COCKROACH HOSTS (BLATTODEA) IN A NATURAL FLORIDA HABITAT

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ABSTRACT

Over a 3-year period 1,359 evaniids, representing four species, were collected in a mature sand pine habitat at the Archbold Biological Station in south-central Florida. All species fly for at least six months of the year and show annual fluctuations in abundance. Seventeen species of cockroaches occur at the ABS; the most probable hosts for evaniids are members of the genera *Parcoblatta, Ischnoptera,* and *Cariblatta.*

Key Words: Parasitoids, ecology, behavior, population density.

RESUMEN

Durante un período de 3 años, 1,359 evaníidos, representando 4 especies, se colectaron en un habitat de pino de arena en la Estación Biologica Archbold (EBA) en el centro de la Florida. Todas las especies vuelan durante por lo menos 6 meses del año y muestran fluctuaciones annuales en abundancia. Dieciseis especies de cucarachas ocurren en la EBA. Las hospederas probables de los evaníidos son miembros de los generos *Parcoblatta, Ischnoptera* y *Cariblatta.*

Evaniid wasps are a small group of specialized solitary parasitoids, living only in egg cases of cockroaches. What little is known about host relationships (see Townes 1949, Roth & Willis 1960) suggests that each species of evaniid is specialized to attack egg cases of a particular size, sometimes those of a genus or closely related genera of cockroaches. This is not surprising, as different cockroaches deposit their egg cases in different situations, and the egg cases themselves differ in size and structure. It is difficult to get direct information on hosts and general ecology of evaniids because they